PB-229 990

STRIPPABLE LOW-SULFUR COALS OF SOUTHEASTERN MONTANA. PART 2. MARKETS FOR MONTANA COAL

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Montana Bureau of Mines and Geology

Prepared for:

National Air Pollution Control Administration

August 1970

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PB 229 990

STATE OF MONTANA
Forrest H. Anderson, Governor

BUREAU OF MINES AND GEOLOGY
Uuno M. Sahinen, Director

August 1970

PRELIMINARY SUMMARY REPORT

OF

STRIPPABLE LOW-SULFUR COALS OF

SOUTHEASTERN MONTANA

by

Robert E. Matson and Wayne A. Van Voast

S. L. Groff, Project Director

Part 2

MARKETS FOR MONTANA COAL

by

Cameron Engineers
Denver, Colorado

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U S Department of Commerce
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Economic information included was prepared for
the Montana Bureau of Mines and Geology by
Cameron Engineers, Denver, Colorado

This report has been prepared in cooperation with the Office
of Fuel Resources, National Pollution Control Administration
Department of Health, Education, and Welfare

Grant No. 69A-2901D

MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY
Butte, Montana
August 1970

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MARKETS FOR MONTANA COAL

Introduction

The future markets for Montana coal will be the electric power generating industry and the synthetic fuels industry. Due to the low sulfur content of most Montana coals, they will be used for power generation outside the state as well as within. Synthetic fuels plants using Montana coal will be located within the state. Relatively small consumers of coal will continue to use coal in the state for a variety of purposes.

Montana contains vast deposits of coal, but those deposits that are amenable to low-cost surface mining will be the first to be used in large quantities. These deposits are located principally in the eastern one-third of the state and this location dictates that markets in the middle west will be more available than those on the west coast. The competition of huge coal reserves in nearby Wyoming will bar the central and southern Rocky Mountain markets from supply by Montana.

Looking into the future to 1990, a number of changes will occur which will alter the scope and direction of Montana's coal demand from what it has been prior to 1970. The present fervor concerned with the protection and quality of the atmosphere will increase. Montana's coal is mostly low in sulfur and will become increasingly more in demand as more stringent and tighter limitations are put on the sulfur content of coal burned in various parts of the U. S. Montana coal will be exported to existing coal plants principally in the middle west to blend with high sulfur coal available in that area so the blend of coals burned will satisfy the laws.

It has been predicted by Walter J. Hickel, Secretary of the Interior, that a grid of regional high-voltage transmission lines will tie various sections of the country together within 10 years.[1/] Some of these lines will pass through Montana and, once built, future power plants will be built at coal mines near these interties, with several plants possible in Montana.

The reserves of petroleum and natural gas within the 48 conterminous United States are decreasing and the need to supplement them is becoming readily apparent. One of the means for supplementing the conventional fuel resource supplies is to convert coal to petroleum-like materials and into pipeline gas substitutable for natural gas. Low-cost coal is a prerequisite for the conversion process if the products are to be economically competitive. The coals recoverable by surface mining in Montana will be attractive to such an industry and will cause a number of conversion plants to be located in Montana.

Intrastate Use of Coal

The predominate use for coal in Montana at the present time is for fuel in the generation of electric power. The Federal Power Commission forecasts an increase in power demand in Montana from 1,460 megawatts in 1970 to 2,590 megawatts in 1980 and to 4,700 megawatts in 1990.[2/] The values presented apparently do not include a portion of the eastern part of the state but the rate of increase is significant, 5.90 percent per year for the decade of the 1970's and 6.14 percent for the decade of the 1980's. Whereas most of Montana's electric power is presently generated in hydro plants, most of the

usable sites for such plants have been used and most future expansion will come from thermal plants, both fossil-and nuclear-fueled. With rapidly changing economics the breakdown between the two in the future is a bit confused, but it would appear that nuclear might capture 5 percent of the Montana power market in 1980 and 15 percent in 1990. The tendency will be for the thermal plants to run base-loaded and for the hydro facilities to take the swings and to furnish peaking power. It appears that hydro power will increase by about 800 megawatts during the decade of the 1970's and another 600 megawatts in the following decade. If the anticipated hydro power becomes available, there will be need for 330 megawatts of additional thermally-generated power in Montana during the next ten years. For the decade of the 1980's, the difference between the increase in hydro power and the increase in demand will be 1,600 megawatts. Should nuclear power supply 500 megawatts then fossil fuels, probably coal, will supply the remaining 1,100 megawatts. If the entire fossil fuel-fired load is satisfied with coal, the additional requirements by 1980 are 1.5 million tons per year with an additional 5.0 million tons per year required by 1990.

Magnetohydrodynamics (MHD):

The values for coal described above are based on conventional conversion of coal to electric power. By the time the demand for coal-fired power develops, one of several possible improved systems for converting coal to electric power may be available. One of the more promising systems is called magnetohydrodynamics (MHD). In this process, some of the energy in coal is converted to power by passing a very hot, ionized flame at high velocity through a zone inside of a

powerful magnet. The spent hot gases then are utilized in a conventional power plant. This process is being tested and if it proves applicable, three benefits would result. First, the overall thermal efficiency of such a plant may be 60 percent, over one and one-half times that of a conventional plant and it would require only about 2/3 as much fuel for the same amount of generated power. Second, with less inefficiency, the need for cooling water is cut to about half or less of that needed for a conventional plant. Third, the effluent gas stream from a MHD plant would cause far less air pollution than would a conventional plant of the same capacity. By the time these power developments are needed in Montana, a water supply will be a very serious consideration and protection of the environment will even more important than it is today.

Power for Export:

The increase in coal demand for use in electric power generation in 1980 and 1990, 1.5 million tons and 5.0 million tons annually, respectively, was based on the power needs in the state. It is probable that large quantities of power generated in Montana will be exported to other areas during the next twenty years. The power for this development will be generated from coal at mine-mouth plants.

The whole proposition of exporting large quantities of power hinges upon the construction of a network of extra-high voltage transmission lines tying several regional areas of the U. S. together--regional interties. The idea of regional interties has been based on the fact that the peak demand for electric power in various regions occur at different times,

both on a daily basis and on a seasonal basis. In effect, the unused capacity in one region during off-peak conditions would be supplied to another region to assist it over its peak. This would save building generating capacity in each region just for peaking purposes.

The concepts of regional interties have been described by the Department of the Interior.[3/] Some of the schemes presented by Interior show interties from the midwest passing through Montana to the Pacific Northwest. Two major lines which connect metropolitan areas such as Chicago, Minneapolis, St. Louis and Kansas City combined in Montana enroute to the State of Washington where an intertie to the Pacific Southwest already exists. Coal-fired, mine-mouth power plants in Montana would put power into the interties for transport to the East or to the West or conceivably in both directions, if needed.

The prospects for early construction of a network of regional interties became apparent from Interior Secretary Hickel's statement before a Senate Appropriations Committee[1/] that a national power grid was needed and that one should be built in ten years or less. As previously stated, but repeated for emphasis, the export of large amounts of power from Montana depends on the installation of the delivery facilities for some purpose beyond only making the export possible, and regional interties are the key.

The advent of a synthetic fuels industry in Montana will also affect power generation. Plants making synthetic fuels from coal, as will be described later, also produce a by-product called char which is a fuel for power plants. As a matter of fact, most of the proposed synthetic fuels processes will not be economically feasible unless there are power plants

to utilize the char they made. Technological limitations in the development of synthetic fuels processes make their commercial application unlikely before about 1977. When such plants are built, they will probably be parts of an energy complex converting coal to synthetic petroleum, pipeline gas and electric power.

It appears that the developments in synthetic fuels and regional interties will result in the construction of facilities at about the same time. The need for power plants to supply the interties should develop simultaneously. The first such complex consisting of a 2,000 megawatt power plant and one synthetic petroleum or pipeline gas plant may be anticipated in 1980. The plant for making synthetics will be described below, but it is important here that regardless of the type of primary product the plant makes, it will also produce a by-product char which must be used in the power plants. The quantity of char to be utilized will be equivalent to 2.1 million tons of coal annually. The 2,000 megawatt power plant, operating at a load factor of 90 percent will require 8.4 million tons of coal annually. If char equivalent to 2.1 million tons a year is available from a synthetic fuels plant, the need for coal is reduced to 6.3 million tons a year.

By 1990 the number of such complexes may be expected to increase to four with an electric power output of 8,000 megawatts. The coal requirement for power generation would then be over 33 million ton per year without char and about 25 million tons per year together with char.

Synthetic Fuels from Coal:

As mentioned above, it seems that developments being made now on processes for liquefying and gasifying coal will make

commercialization possible in Montana in 1980. The current dilemma in the natural gas supply situation would suggest that the first synthetic fuels plant in Montana would be for the production of natural gas supplement. Whether the first plant is for gas or oil is not important at this point. An economic size might be 300 million cubic feet of gas or 70,000 barrels per day of oil. Either one requires an input of average Montana coal of 11 million tons per year and each makes enough char to be equivalent to 2.1 million tons per year.

The complex of a synthetic fuels plant and a 2,000 megawatt power plant would require 17.3 million tons of coal per year. If by then some other use is known for char, the synthetic fuels plant would require 11 million tons annually and a char product equivalent in heating value to 2.1 million tons of coal per year would be available.

In 1990, when four complexes will be in operation, the preceding values will be four times as large. The total coal requirement would be 69 million tons per year of coal.

XEROX

Montana Coal for Export

There are three distinct reasons which make the strippable coals of Montana particularly attractive for export to other states. First is the relative low cost of coal recovery. The average estimated selling price of coal from 15 deposits in the state is $1.39 per ton, as indicated in the table on the following page. Prices range from $1.16 per ton from the Poker Jim, Lookout deposit to $1.77 per ton from the Poker Jim, O'Dell Creek deposit.

The second reason is the low sulfur content of Montana coal which makes it attractive for burning as fuel in locales where the burning of high sulfur coal is prohibited. The low sulfur advantage offered by Montana coal may, however, diminish in years to come as will be discussed later in the report.

The third reason making Montana coal attractive for export is the fact that the coal is available in large quantities from relatively compact areas. Thus, it is possible to write long-term contracts for large coal orders and fill the orders from operations in one general location.

The one glaring handicap to utilization of Montana coal is its geographical location--it is far away from the nation's major coal consumption centers. Illinois for example, the state with the largest demand for coal for power generation purposes, is about 900 miles from Montana's coal resource. Missouri and Wisconsin are at about the same distance; Minnesota, Kansas and Eastern Nebraska are only about 300 miles closer.

Table 1

MONTANA COAL, Indicated Reserves and Price
(Price range is -5% to +15% of Indicated)

	Reserves Million Tons	Percent of Reserves	Price, Indicated $/Ton	Contribution to Avg., $/Ton
Broadus	737	7.50	1.39	0.1041
Birney, Brewster-Arnold bed	321	3.26	1.77	.0577
Colstrip	1,440	14.65	1.36	.1991
Decker, Bed No. 1	664	6.75	1.74	.0830
Decker, Bed No. 2	100	1.02	1.54	.0176
East Decker	322	3.28	1.54	.0504
Hanging Woman Creek, Anderson bed	1,709	17.38	1.30	.2259
Hanging Woman Creek, Deitz bed	1,183	12.03	1.65	.1985
Moorhead, Anderson bed	975	9.92	1.34	.1328
Moorhead, Canyon bed	522	5.31	1.51	.0800
Otter Creek	754	7.67	1.23	.0942
Pine Hills	199	2.02	1.39	.0281
Poker Jim, Lookout	441	4.48	1.16	.0520
Poker Jim, O'Dell Creek	198	2.01	1.77	.0356
Sand Creek	267	2.72	1.21	.0328
	9,832	100.00		1.3918

But, despite these seemingly great distances, the most attractive future markets for Montana coal most assuredly will be found in the Midwest. Potential markets to the south are stifled by the existence of extensive coal reserves in Wyoming. Wyoming coal is not only similar in quality and cost to Montana coal but is obviously closer to markets in Colorado and also to excellent rail connections. Prospects for marketing Montana coal in the West are no better. There are no existing large markets and none are anticipated.

The heating value of Montana coal is generally lower than those of the midwestern coals with which Montana coal will compete. In most cases, the ultimate selection of a coal for a particular use is based upon the amount of heat obtainable from one ton of the coal. Therefore, to satisfy a given heat requirement, Montana coal is generally required in greater tonnages than a typical midwestern coal. Montana coal is penalized by its low heating value in another way. The cost of rail transportation of coal is based on weight, and it is fundamental that for a given weight, more potential heat can be transported in a high heating coal than in a low heating value coal. In effect, the cost of moving low heating value coal includes the cost of moving the impurities which cause the low heating value. There may be ways to reduce the transportation costs of low heating value coal. For example, removing part of the water from Montana coal prior to shipping might result in a slightly lower price at its ultimate destination. This possibility will be discussed later in this report.

Export of Montana Coal for Power Plants:

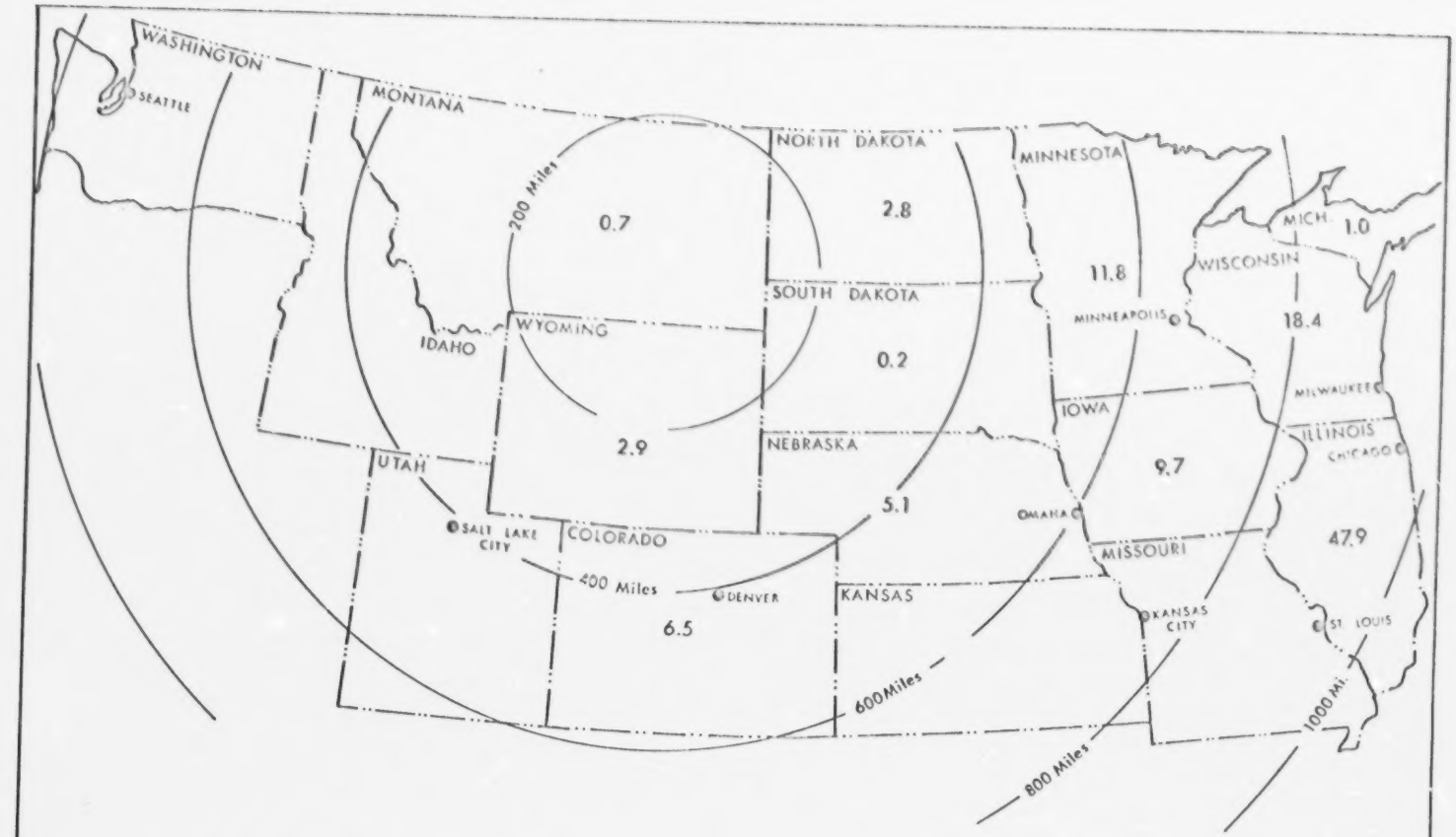
Power plants consume about half of the coal currently mined in the United States. The series of three maps starting on the next page show the predicted coal requirements of power plants where Montana coal might conceivably be used for the years 1970, 1980 and 1990. The numerals within the state borders indicate, in millions of tons, the amount of Montana coal which would be needed to meet the predicted requirements. Information was not available for all states. The distances indicated by the concentric circles are from a point east of Billings and it should be pointed out that rail mileage to a given destination would be substantially greater.

Montana coal is already being shipped from Colstrip to Cohasset in northeastern Minnesota. The reason for this utilization is primarily economy. Montana coal is cheaper to burn at that location than other coal.

Sulfur Limitations:

Although the hazard of sulfur oxide emissions to the atmosphere is a controversial subject, various governments, by legislation, are limiting the sulfur content in coal burned. The restrictions vary from one locality to another and are changing rapidly. The restriction placed on sulfur in coal burned in power plants in Chicago is a good indication of what may be expected elsewhere in the near future. By mid-1970 the maximum sulfur content of fuel burned in power plants in the Chicago area was lowered to 1.8 percent. Starting January 1, 1972 the limit will be 1.0 percent.

Coal mined in Illinois generally contains about 3 percent sulfur. Illinois coal, therefore, will have to be blended

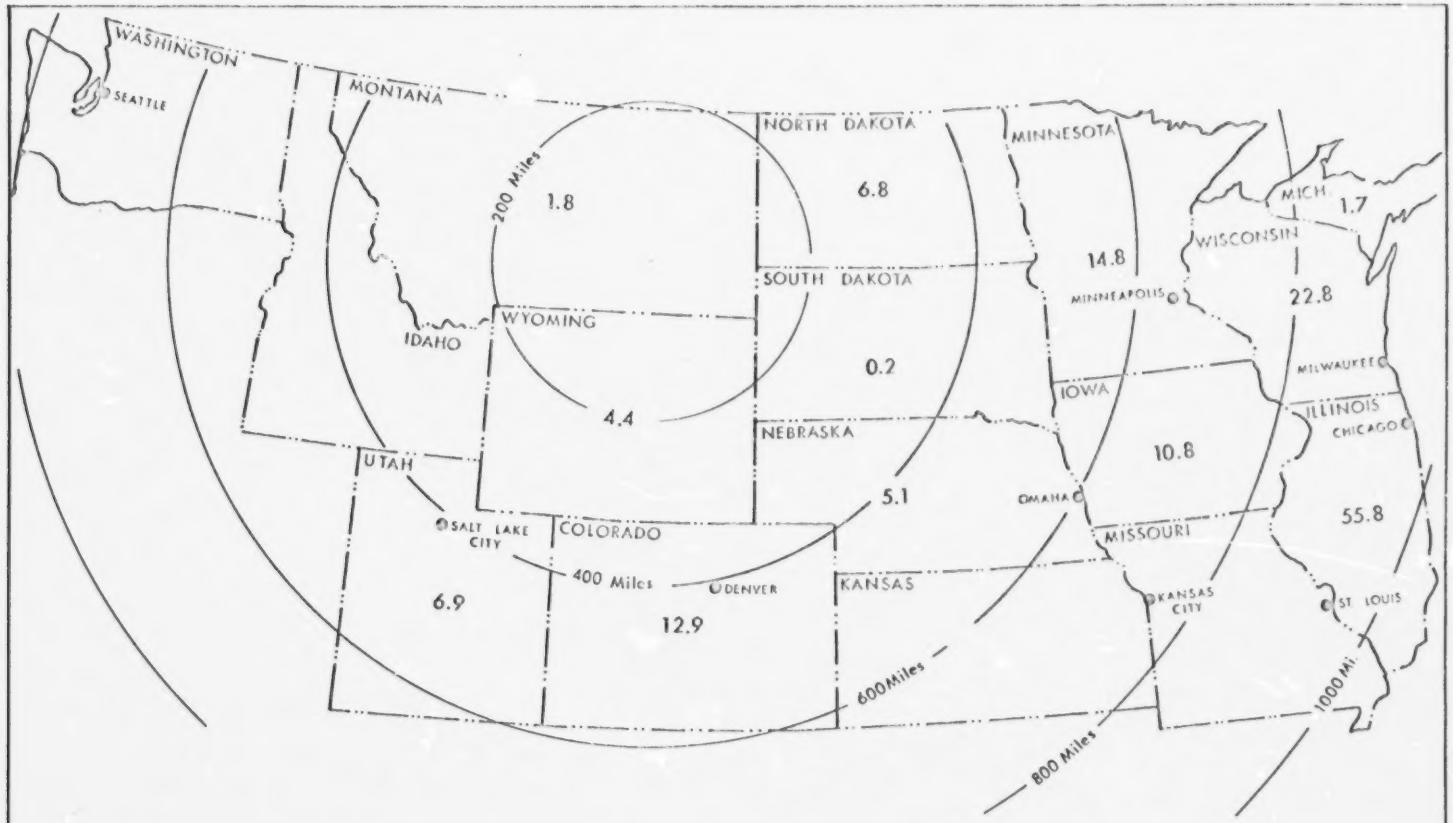


Coal Required for Power Generation
in 1970

Millions of Tons of Montana Coal Equivalent

Conventional Conversion Based on FPC Regional Advisory Reports, 1969

Figure 1

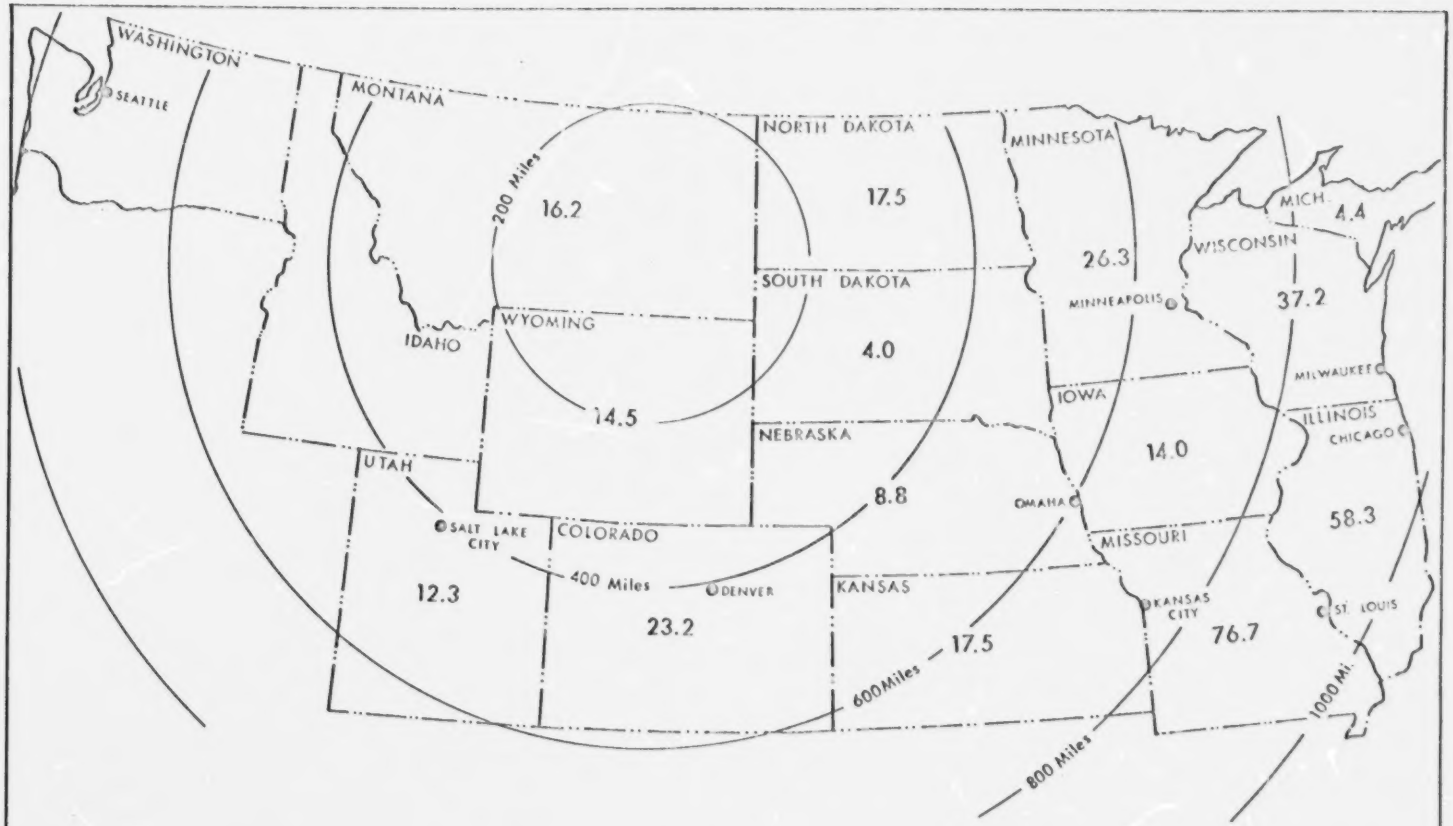


Coal Required for Power Generation
in 1980

Millions of Tons of Montana Coal Equivalent

Conventional Conversion Based on FPC Regional Advisory Reports, 1969

Figure 2



Coal Required for Power Generation
in 1990

Millions of Tons of Montana Coal Equivalent

Conventional Conversion Based on FPC Regional Advisory Reports, 1969

Figure 3

with low-sulfur coal to comply with the current maximum. Starting in 1972 the blend will consist mostly of low sulfur coal. This represents a large potential use for Montana coal, the economics of which will be presented later. Similar situations are expected to develop in other industrial centers in the midwest.

The impact of laws limiting the sulfur content of coal burned for any purpose may be of short duration. At the present time, a number of organizations are working to perfect schemes which will remove the sulfur oxides from the stack gases of power plants. When they are perfected, and if the cost of removing the sulfur oxides is reasonable, permission will very likely be granted to once again burn high sulfur coal in power plants.

If the sulfur limitations are short-lived, producers in Montana may not be able to produce large quantities of coal for a relatively short period of time because of the capital investment required. On the other hand, potential consumers in the midwest may not be willing to sign long-term contracts for coal delivery.

It has recently been reported 4/ that Commonwealth Edison Company of Chicago is starting to acquire reserves of high sulfur coal in Menard County, Illinois, about 170 miles from Chicago. The coal will not be mined immediately nor burned until effective sulfur removal devices are installed. The implication is clear. Commonwealth Edison Company will use Illinois coal in their plants if it can be legally burned and at lower total cost than that of coal imported from Montana. The same situation may be expected to exist in other potential market areas for Montana coal.

Sulfur Removal from Stack Gases:

Several experimental installations for removing sulfur from power plant stack gases are in operation or are under construction. The processes being tested include contacting the gases with dry alkaline salts, scrubbing them with aqueous solutions and adsorbtion of the sulfur oxides on resins. Some of the processes recover by-product sulfur for sale as sulfur or sulfuric acid.

There is no perfected commercial process for removing sulfur oxides from power plant stacks and it follows that costs for the removal are not accurately known at the present time. Most estimates, based on cleaning stack gases which result from burning coal containing 3 percent sulfur, run from $2.00 to $4.00 per ton of coal burned. For a coal with a heating value of 12,500 Btu per pound this amounts to 8¢ to 16¢ per million Btu. These costs include return on investment and are realistic. The lowest value being discussed by people working in the field is 5¢ per million Btu. This cost is important in any consideration of exporting Montana coal in competition with high-sulfur domestic coal. Keeping in mind that large-scale export of Montana coal can occur only if long-term supply contracts can be negotiated, the cost of removal of sulfur oxides from stack gases must be considered for the ensuing 35 years. On this basis, the lower end of the cost estimates, 5¢ to 10¢ per million Btu, will be used as realistic values over the long period of time.

Unit Trains:

Unit trains consist of sets of haulage equipment dedicated to the transport of a specific commodity. They are designed to

be rapidly loaded at the point of origin and rapidly unloaded at one destination. Trains move in both directions on a predetermined schedule with minimum idle time. The concept originated in 1959 and, as reduction in transportation costs became evident, the number of unit trains has grown 5/. By the end of 1967, 327 coal mines were shipping coal by unit trains at an annual rate of over 103 million tons, almost one-fifth of the coal produced that year.

Shipping Montana coal out of the state will likely be accomplished with unit trains. A brief description of a typical, large unit train operation follows. The train itself consists of 80 to 100 steel, hopper-bottom cars each with a capacity of 100 tons of coal and appropriate traction equipment. The capacity of the train is 8,000 to 10,000 tons of coal. Cars are loaded by moving the train continuously under a large supply hopper or pile at a rate of about 22 feet per minute. A car is loaded to capacity in 1.5 minutes, an average loading rate of 4,000 tons per hour, and the entire train is loaded in 2 to 2-1/2 hours. The loaded train proceeds to its destination averaging about 25 miles per hour. Upon arrival at the destination, the train is passed over track hoppers at continuous speeds of about 1 to 2 miles per hours. The hopper bottoms are opened automatically as the cars pass over the hoppers and the train is unloaded in less than two hours and is on its way back to the point of origin.

Ownership of the facilities is dependent upon conditions. Frequently, the shipper owns and operates the loading facility, the carrier owns and operates the unit trains, and the consumer owns and operates the unloading facility. The chart on the next page, Unit Train Railroad Transportation Rates for Coal, is

Figure 4

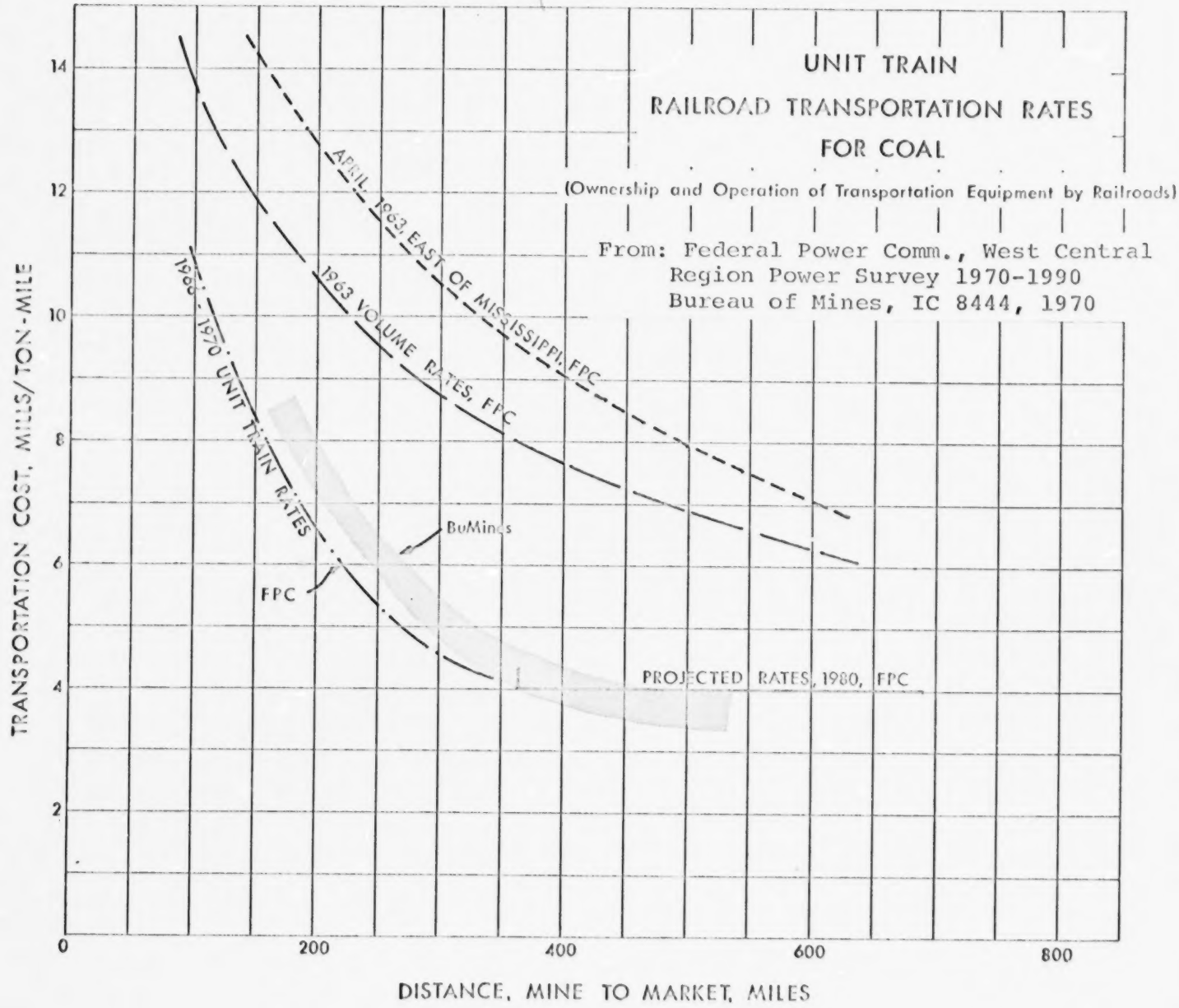


Figure 4

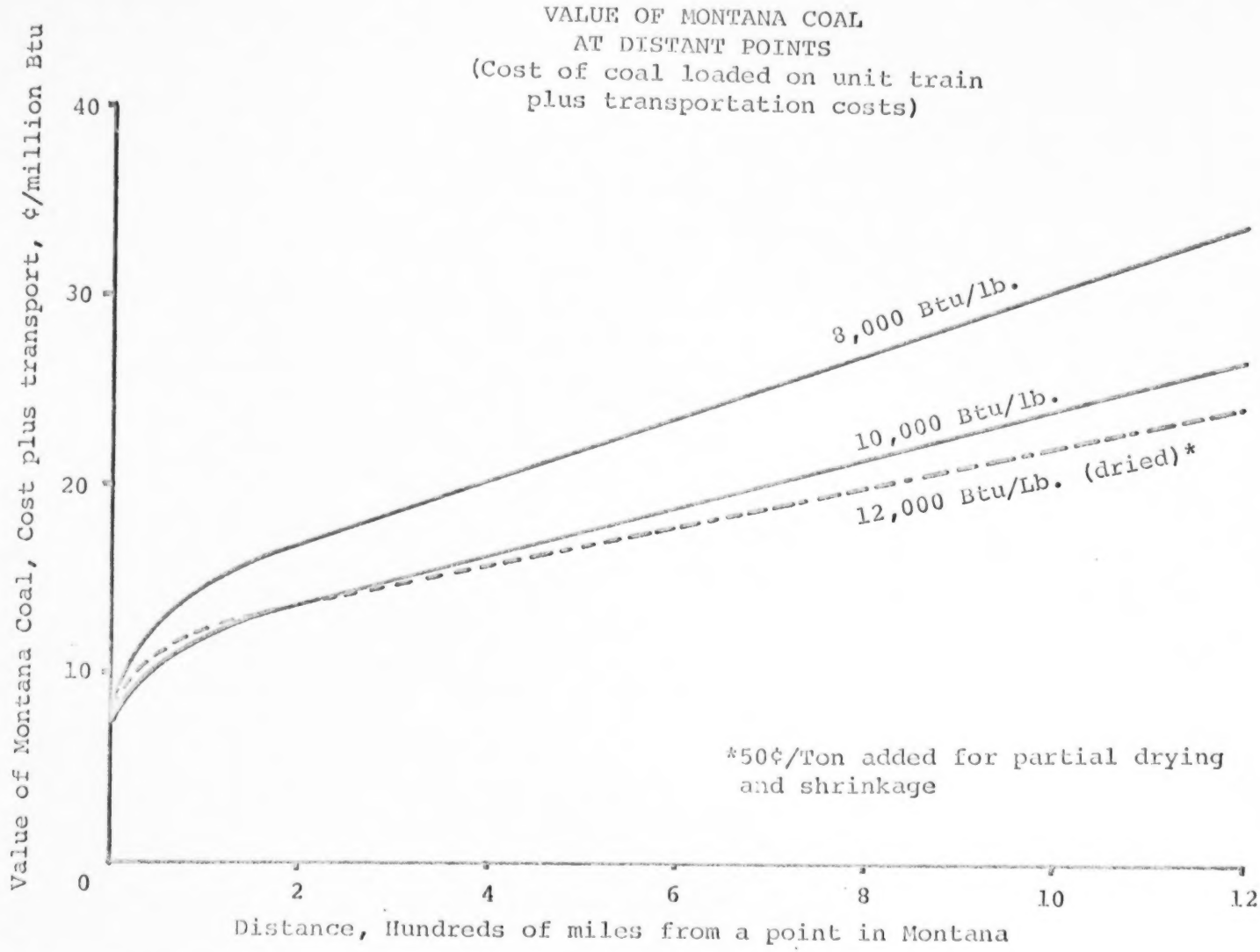
based on such ownership. However, to obtain minimum delivery cost the supplier or the consumer may own and supply the coal cars.

The chart indicates that, in 1963, typical volume rates for coal were about 1¢ (10 mills) per ton-mile for moving coal a little over 200 miles. The cost decreases with increased distance to about 0.7¢ (7 mills) per ton-mile when the distance is increased to about 600 to 800 miles. The cost for moving coal by unit train is only 0.6¢ (6 mills) and less than 0.4¢ (4 mills) per ton-mile for the same respective distances. The Federal Power Commission forecast to 1980, basis for the lower line curve on the chart, shows the cost of moving coal by unit train levelling at 4 mills per ton mile for distances in excess of about 360 miles. Current evidence and the Bureau of Mines data indicate that even lower costs may be attained for long hauls of 600 miles or more.

Economics of Exporting Montana Coal

The chart on the following page shows the value (the sales price) of Montana coal at various distances from a given point in Montana. It is a generalized chart, based on an average coal cost of $1.40 per ton loaded on unit train cars regardless of heating value. The cost of transportation by unit train is based on the Unit Train chart on the preceding page. Some liberties were taken in plotting the curves such as eliminating an antinode at about 350 miles and lowering the cost of transportation at 1,000 miles distance to 3.5 mills per ton-mile. The two solid curves show the effect of heating value on the value of delivered coal. The value of 8,000 Btu-per-pound coal loaded on a unit train and transported a distance of

Figure 5


VALUE OF MONTANA COAL
AT DISTANT POINTS
(Cost of coal loaded on unit train
plus transportation costs)
Value of Montana Coal, Cost plus transport, ¢/million Btu
40
30
20
10
0
8,000 Btu/lb.
10,000 Btu/lb.
12,000 Btu/Lb. (dried)*
*50¢/Ton added for partial drying
and shrinkage
2
4
6
8
10
12
Distance, Hundreds of miles from a point in Montana

1,000 miles is 30.4¢ per million Btu compared to 24.4¢ per million Btu for 10,000 Btu-per-pound coal under the same conditions. The values of loaded coal for the two curves are 8.7¢ and 7.0¢ per million Btu, respectively. The additional costs are due to transportation.

The dashed curve is related to the others and is described below.

Possible Reduction of Transport Cost by Upgrading Coal:

It is obvious that, with a fixed cost per ton-mile for transporting coal to a destination, the higher the heating value per unit weight the lower will be the cost of Btu's delivered. Or, put another way, the cost of moving inert material in coal adds to the cost of the active portion of the delivered coal.

Montana coal is relatively high in moisture content, frequently more than 30 percent. It is generally low in ash content. If a system could be developed to remove some of the moisture and mineral matter from mined coal and to concentrate the burnable portion in a product with 80 percent of the original weight of the coal, the heating value of the purified coal would be increased 25 percent over the mined coal value. For example, a coal with a heating value of 9,600 Btu per pound when cleaned and dried to 80 percent of its original weight would have a heating value of 12,000 Btu per pound. This coal would be transported to market at lower transportation cost per million Btu than the mined coal discussed in the preceding paragraphs. However, two additional costs must be added to the coal loaded for shipment. First, there is the shrinkage of 20 percent in weight from the mined coal. If again the value

of coal is taken to be $1.40 per ton, the weight shrinkage due to removal of moisture and mineral matter causes an increase in value of the purified coal of 35¢ per ton. Second, there is a cost of moisture and mineral matter removal. Without investigating the subject, a value of 15¢ per ton of purified coal is added to cover this processing step. Thus, the value of the purified coal loaded into a unit train for shipment is $1.90 per ton or 7.9¢ per million Btu.

Using the same transportation costs as in the cases of shipping mined coal, the purified coal attains a value of 12.5¢ per million Btu at a distance of 100 miles, indentical with the cost of the 10,000 Btu-per-pound coal. At greater distances the value of the purified coal is lower than the other two cases, being 22.4¢ per million Btu at a distance of 1,000 miles.

The prospect for reducing the sales price of Montana coal delivered to a distant destination by processing the mined coal to remove inerts seems favorable. It must be emphasized that the cost of processing quoted above has not been calculated in detail and can not be used with any assurance--it should be considered only as an indication of the range of such a cost. Further, driving the inherent moisture from coal generally involves size reduction to the extent that the processed coal may not be transportable in usual unit trains. The processed coal might also be more subject to spontaneous combustion which would make it awkward to transport and to stockpile.

The potential reduction in the delivered price of Montana coal by 5 percent to 10 percent makes the concept of processing the coal before shipping attractive. Despite some possible

handicaps, such a step might make Montana coal more competitive in long distance markets such as Illinois and Missouri. It is recommended that this subject be further investigated.

Competition for Montana Coal:

Several midwestern states contain large reserves of coal the use of which would in direct competition with Montana coal. As stated previously, however, midwestern coals generally exhibit a considerably higher sulfur content than does Montana coal and it is the added cost of sulfur removal which tends to make Montana coal competitive with typical midwestern coals. In the following discussion, Illinois coal is used to exemplify the competition for Montana coal.

Illinois coal is furnished to several large power plants in the Chicago and St. Louis areas. Typical coal costs at the larger power plants in the two areas are shown in the table on the following page. The data are for calendar year 1968.6/ Referring to the table, the cost of coal FOB plants ranges from 19.3 to 32.5¢ per million Btu. The average (weighted) coal cost per million Btu is 23.9¢.

Earlier in this report, the cost of removing sulfur oxides from stack gases resulting from burning high sulfur coal were estimated to be in the range of 5 to 10¢ per million Btu.

Table 2

COST OF ILLINOIS COAL IN LARGE POWER PLANTS
Data from Steam-Electric Plant Factors,
1969, published by National Coal Association

Plant Name	Tons Coal per Year, thousands	$/Ton, FOB	Heating Value Btu/lb.	Cents per Million Btu	Contr. to Average ¢/MM Btu
Chicago Area					
Ridgeland	1,250	5.88	10,078	32.5	1.924
Kincaid	2,196	4.29	9,967	21.5	2.236
Joilet	4,105	4.87	10,986	22.7	4.415
Fisk	1,011	5.92	9,997	31.9	1.528
Crawford	1,227	5.80	9,984	29.4	1.708
Will County	3,122	5.72	10,247	27.9	4.126
Southern Illinois					
Joppa	3,388	4.40	11,404	19.3	3.098
St. Louis, Illinois					
Cohokia	253	4.99	11,291	24.2	.288
Venice	815	4.91	11,511	22.7	.876
St. Louis, Missouri					
Meramec	2,266	4.76	11,172	21.9	2.352
Sioux	1,464	4.52	11,339	20.0	1.386
	21,097				23.937

The resulting Illinois coal costs including the cost of sulfur removal are summarized in the following table.

Summary of Illinois Coal Costs
¢ per MM Btu

	W/o Sulfur Removal	W/ Sulfur Removal*
High	32.5	37.5 - 42.5
Low	19.3	24.3 - 29.3
Average	23.9	28.9 - 33.9

*Sulfur removal costs estimated to range from 5 to 10 ¢ per million Btu

The rail distance from Montana to the Chicago and St. Louis areas is approximately 1000 miles. If Montana coal is shipped to these areas as 8000 Btu coal, the average sales price, including transportation costs, would amount to 30.4¢ per million Btu. The sales price is based on an average value of coal, after it is loaded on a unit train at the point of origin, of 8.7¢ per million Btu. The 8.7¢ figure was developed earlier in this report and was suggested to be accurate to within minus 5% and plus 15%. The higher limit would add 1.3¢ to the cost while the lower limit would reduce the cost by 0.4¢ per million Btu.

The foregoing comparison of Montana and Illinois coal costs was based on average values for mining, transportation and sulfur removal costs. It should be pointed out that the costs thus developed should be used with a certain degree of care. To obtain a realistic comparison of coal costs in a specific situation would require the development of considerably more detailed information than was deemed appropriate for the purpose of this report.

In the immediate future, perhaps for a five-year period, low sulfur Montana coal may be in strong demand in such places as the large Illinois market area where strict limits have been placed on the sulfur content of coal burned for power generation or other uses. During this same period, it is doubtful that widespread practice of sulfur removal from stack gases will become a reality. High sulfur Illinois coal will be burned only if variances from local law are approved by local authorities. When sulfur removal processes do become commercially applicable at costs approximating those suggested above, the demand for Montana coal will depend solely on economic considerations.

On the average, the cost of 8,000 Btu Montana coal falls into the middle of the range of local coal costs which include the cost of sulfur removal. A wide range of coal costs and heating values were averaged to come to this conclusion. It appears that only the lower-cost, higher-heating value Montana coals will be able to compete with local coal in distant markets, and that there will be instances when even Montana's cheapest coal will not be competitive. Montana's lower-heating value coal will find competition extremely keen in an area like Illinois. In other areas where there is no readily available coal, like Wisconsin, Minnesota, Iowa, western Missouri, Kansas and Nebraska, Montana coal should be competitive.

In several respects, Montana coal opportunities may improve with time. Montana has very large deposits which will be recovered by surface mining methods whereas the competitive coal of the midwest will be recovered in growing amounts by underground means. The Coal Mine Health and Safety Act of 1969 is

currently being put into full force and it will no doubt cause an increase in the cost of coal from underground mines. This will improve Montana's coal prospects. While Montana has tremendous reserves which can be dedicated to power production, many areas of the midwest have consumed the most easily recoverable coal and are finding additional supplies more difficult to locate. These potential advantages for Montana coal could be further augmented if a method is found to reduce transportation charges, such as the partial drying suggested above, or if some improvement is made in rail delivery costs.

SYNTHETIC FLUID FUELS FROM COAL

Introduction

Fluid fuels, petroleum and natural gas, currently account for about three-fourths of the total energy supply in the United States. The proved reserves of petroleum and natural gas are enough to supply the needs of the country at the current rate of usage for less than 15 years. The demand for each is projected to increase while the rate of finding new supplies is decreasing. There is a need to find supplemental sources for these important energy fuels. One of the possible solutions is to convert coal to synthetic petroleum and pipeline gas.

Methods for gasifying coal date back to the early nineteenth century when coal gas was used to light areas of London. That gas, however, was not comparable in heating value to natural gas. Conversion of coal to a high heating value substitute for natural gas has been accomplished during the past 30 years, but only in the last few years as a result of new processes has that conversion approached economic feasibility.

Coal was converted to petroleum products during World War II. The methods used could be justified only by the conditions existing at that particular time. Once the conflict had ended the costs were higher than for similar products made from natural petroleum. During the past ten years, methods have been developed to make gasoline and other petroleum products from coal at costs which seem to be competitive with those of products made from natural petroleum. Actually, these processes have been demonstrated only in the laboratory and several more years of development will be required before commercial plants could be considered.

The reserves of coal in the U. S. are many times greater than the combined reserves of oil and gas. Using the petroleum and natural gas proved reserves estimated by the American Petroleum Institute (API) and the American Gas Association (AGA), [7] the total can be represented by a heating value of 509 quadrillion Btu. The heating value for recoverable coal reserves, half of Averitt's [8] coal determined by mapping and exploration, is about 15,600 quadrillion Btu, or over 30 times the energy content of oil and gas combined. The facts that coal can be converted into oil and gas and that it can be recovered in such prodigious quantities make it an attractive raw material for supplementing the fluid fuels.

The Office of Coal Research

The Congress created the Office of Coal Research by passing Public Law 86-599 in July, 1960. The Office was set up in the Department of the Interior and is charged with finding new markets for coal by supporting contract research. The Office of Coal Research (OCR) now operates with an annual budget of about $16 million. More than half of that amount is spent on developing processes for converting coal to synthetic pipeline gas and synthetic petroleum. Some of OCR's active projects are described in the following paragraphs.

Project Gasoline:

OCR contracted with Consolidation Coal Company in 1963 to develop the latter's ideas of converting coal to premium gasoline. Laboratory investigations indicated that the process was workable and that gasoline might be made from coal to sell in the range of 11¢ to 13¢ per gallon. A pilot plant was built at Cresap, West Virginia to test the ideas on a larger scale.

The plant was completed in May, 1967 and attempts to make it completely operational continued until the end of 1969.

The Cresap plant is currently shut down and undergoing a reevaluation by an outside consulting engineering organization. As a result of a project evaluation conducted in 1968, the selling price of gasoline from coal was estimated to be 15.5¢ per gallon at the plant. This is slightly higher than conventional gasoline in the areas used in the study indicating that synthetic gasoline was just short of being competitive at that time.

This is OCR's most advanced process for making petroleum products from coal. Since the evaluation was completed process improvements have been made which just about cancel the inflation of costs due to higher capital and labor charges. Consequently, the synthetic product remains a marginal competitor. Commercialization of this process will not occur before 1977.

Project C.O.E.D.

Project C.O.E.D. is supported by OCR funds and the investigation is being conducted by the FMC Corporation. The principle involved in this process is a multiple-stage carbonization of coal. It produces an oil which can be upgraded to the equivalent of natural crude oil. The process also results in a large quantity of by-product char. The only known use for the char is as fuel for an electric generating plant. A plant producing 30,000 barrels of petroleum-like oil from coal would also produce enough char to fuel a 1,500 megawatt power plant. The utilization of the char will limit the number of C.O.E.D.-type plants in Montana.

The C.O.E.D. process has been developed through small pilot plant testing by FMC Corporation during the period 1962 through 1968. A large pilot plant currently under construction should be placed into operation during the summer of 1970. Commercialization of the process, however, will not occur before 1977.

Montana coal is suitable as a raw material for the C.O.E.D. process but liquid yields of Montana coals are generally smaller than for many other coals. The cost advantage of Montana coal is off-set by the lower yield; thus the process may never gain wide acceptance in Montana.

Hydrogasification of Coal:

The high-pressure hydrogasification of coal to a substitute for natural gas has been under investigation at the Institute of Gas Technology since the mid-1950's. The project was originally funded by the American Gas Association. In 1964 the OCR joined in financing the operation. The process has been developed through laboratory stages. A pilot plant now under construction should be providing operating information by the end of 1970. Economic studies indicate that pipeline gas can be made by this process to sell for about 40¢ to 60¢ per thousand cubic feet depending on the coal source and size of the facility. Gas at this price is not competitive with natural gas in many places, but it does approximate existing prices in some areas. This situation is expected to change in favor of the synthetic gas as a threatened shortage of natural gas becomes reality and the price of natural gas increases. Even so, commercialization of this gasification scheme is unlikely before 1976.

CO_2 Acceptor Process of Gasification:

Investigation of this novel means of gasifying coal has been supported by the OCR since 1964. Gasification is effected by heating coal in a fluidized bed using a flow of activated dolomite both as a heat transfer medium and as an acceptor (Absorber) of carbon dioxide (CO_2). Consolidation Coal Company is pursuing the development with OCR funds. A pilot plant is under construction and should be in operation in early 1971.

Montana lignite and subbituminous coal seem to be well suited for processing to gas by this method but utilization of the by-product char must be considered. This gasification scheme will not be commercialized before 1977. In Montana it is likely that the need for synthetic gas plants of this type will occur coincidentally with the need for electric power plants; a complex containing both is not improbable.

Others:

The Office of Coal Research is supporting several other schemes for gasifying and liquefying coal. They are in lower stages of development or not as pertinent to developments expected in Montana. Some of the projects, the type of process and the principal contractors are:

Pipeline Gas from Coal, gasification, Bituminous Coal Research.
Project Seacoke, liquefication, Atlantic Richfield Company.
Computer Optimization, gasification, West Virginia University.
Coal-Hydrogen Process, gasification, University of Utah.
Low-Ash Coal, liquefication, Pittsburg & Midway Coal Co.
Electrofluidic processing, gasification, Iowa State University.
Arc Processing, gasification, Avco Corporation.

The Bureau of Mines

The U. S. Bureau of Mines has been investigating the production of synthetic fuels from coal for over 30 years. From 1945 to 1954 the Office of Synthetic Liquid Fuels operated within the Bureau and built demonstration plants in Louisiana, Missouri where coal was successfully converted to gasoline and other petroleum-like products by several methods. Large scale investigations of processes known at the time were eventually abandoned, however, because of high production costs.

The Bureau of Mines continues to investigate many processes for both coal liquefaction and gasification. At the present time, the Bureau has developed one particular coal gasification process to the point where plans are being made for construction of a pilot unit if funds are made available. This process uses a relatively small amount of oxygen to gasify coal in a fluidized bed, resulting in a relatively high percentage of methane in the gasifier effluent. The process can successfully handle coking coals which present some problems for other types of gasifiers currently under study.

Even if the Bureau is successful in obtaining funds for its pilot unit in the near future, it is not likely that the process could be commercial before 1979.

Private Industry

Technology:

Several private organizations and their associates are active in developing technology for converting coal to

synthetic fuels. Their total effort in this field is smaller than the Government's effort. Most of the results of the investigations carried out by private interest are proprietary and only the field of endeavor and general progress is publicly known.

Some of these companies and groups and some comments on their activities are listed below.

American Gas Association has been conducting investigations of coal gasification since 1955. They are currently co-sponsoring (with the Office of Coal Research) efforts at the Institute of Gas Technology to develop hydrogasification (HYGAS Project) for which a pilot plant is now being erected.

Humble Oil Company has investigated hydrogenation of coal since World War II. More recently, they have operated a small pilot plant to convert coal to petroleum products.

Continental Oil Company, through their subsidiary, Consolidation Coal Company, has been developing both coal gasification and liquefaction processes since 1955. Under contract to the Office of Coal Research since 1963, Continental completed a pilot plant for converting coal to gasoline in 1967; one for coal gasification is now under construction.

Gulf Oil Company, through its subsidiary, Pittsburg & Midway Coal Company, is involved in studies concerning the deashing of coal to form a quasi-liquid product. The work, which was inherited from the old Spencer Chemical Company, is relatively inactive at the present time.

Consolidated Natural Gas Company and Texas Eastern Transmission Company have co-sponsored investigations of coal and char gasification for several years. The efforts so far, which are directed mainly at making hydrogen, have resulted in the construction and operation of a small pilot plant. Preliminary results of which have been reported as favorable.

El Paso Natural Gas Company though currently inactive, has conducted laboratory investigations of coal gasification in the past. As recently as May 5, 1970 however, the company announced renewed interest in gasification.

Great Northern Railway supports laboratory-scale investigation of conversion of lignite to liquid products.

Atlantic Richfield Company supports the efforts of Hydrocarbon Research, Inc. to convert coal to gasoline using the H-coal process. The work currently involves operation of a pilot plant.

Panhandle-Eastern Pipeline Company and Peabody Coal Company on May 5, 1970 announced they would jointly develop means for gasifying coal with the objective of having a commercial plant operating by the end of the 1970's.

Columbia Gas System announced on May 5, 1970 that it would pursue investigations of means to augment its natural gas supply by the conversion of coal to pipeline gas with the hope of achieving results before the end of the 1970's.

References:

1. Electrical World, 4/20/70, p. 19

2. The Future of Power in the West Region, 1970-1980-1990, Federal Power Commission, 6/69

3. Transmission Study 190, Department of Interior, 1968

4. Coal Mining & Processing, 6/70, p. 9

5. Unit Train Transportation of Coal, Bureau of Mines Information Circular 8444, 1970.

6. Steam-Electric Plant Factors, 1969, National Coal Association